Breaking the 5 Mile per Hour Barrier:

Automated Mapping Using a Normal Depth Calculation

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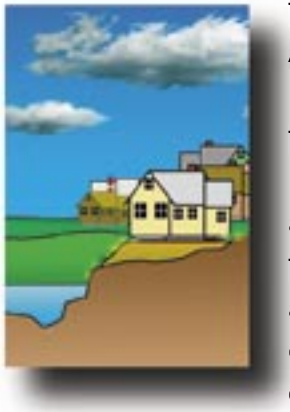
Introduction

In 1998, 53 of Nebraska's 93 counties had no county-wide floodplain maps. At that time an effort was undertaken to have all of them mapped within 10 years. Out of that effort the Nebraska Large Area Mapping Initiative (LAMI) was born. The LAMI tries to maximize both the productivity of the mapping team and at the same time the utility of the final product. The premise of the program cannot be defined by a single computer program or calculation method, but is instead based on the idea that there will be outstanding results when an organization is flexible enough to use any appropriate technology to put the right tool in the hands of a mapping professional. Currently, the Nebraska floodplain mapping team is delineating the 100-year floodplain at a rate of approximately 5 stream miles delineated per staff hour while at the same time producing most of the information necessary for the creation of an Approximate Zone A D-FIRM product.

Technical Basis

The technical basis of the Nebraska LAMI is FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners*, dated February 2002 (and formerly *FEMA 37*). The guidelines for riverine flooding analysis can be found Appendix C and the guidelines for preparing a digital FIRM database can be found in Appendix L.



In Section C.4 of Appendix C, the guidelines for an approximate analysis for riverine flooding are laid out. The two main choices that must be made are the method for determining the approximate flood discharge and the method for determining the approximate base flood elevation. Regional regression equations and a normal depth calculation based on Manning's equation are used in the Nebraska program. The regional regression equations come from a 1993 Nebraska Department of Roads research project (Cordes and Hotchkiss, 1993) that updated the 1974 USGS regional regression equations.

Mapping Steps

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There are eight major steps in the Nebraska floodplain mapping program. Responsibilities for completion of the steps are divided among the mapping professionals composing the mapping team. To assist the mapping team, a set of software tools called the Nebraska Flood Elevation Calculation Tools (N-FECT) have been developed. N-FECT is an extension to ArcView and was written by members of the mapping team.

Simplified descriptions of the eight steps follow. Data inputs and outputs from each step can be found in Table 1. A complete listing of the N-FECT tools and the steps that they are used in can be found in Table 2.

1. **Compilation of Digital Elevation Models (DEMs) for the area of interest.**
2. **Creation of a hydrologically-corrected shapefile of 10-foot elevation contours.**
3. **Creation of a shapefile of the streams and rivers draining at least one square mile.**
4. **Creation of a shapefile of the cross-sections and calculating the base flood elevation for each.**
5. **Creation of a polygon shapefile of the flood zone.**
6. **Digitization of shapefiles of the previously delineated 100-year floodplains (from detailed studies).**
7. **Review of the floodplain for man-made or natural changes.**
8. **Publication of the map in both paper and digital formats.**

Table 1

Data Inputs and Outputs

Step	Input Data	Output Data/Product
1	30-meter DEMs	Filled DEM Grid Flow Direction Grid Flow Accumulation Grid Flow Length Grid
2	10-foot Elevation Contours or USGS Digital Raster Graphics	10-foot Elevation Contour Shapefile
3	Flow Accumulation Grid 10-foot Elevation Contours	Digitized Stream Shapefile
4	Filled DEM Grid Flow Direction Grid Flow Accumulation Grid Flow Length Grid 10-foot Elevation Contours Digitized Streams	Digitized Cross-Section Shapefile Stream Slope Shapefile Base Flood Elevation Contour Shapefile
5	10-foot Elevation Contours Digitized Streams Digitized Cross-Sections Base Flood Elevation Contours	Approximate Flood Zone Shapefile
6	Scanned Study Maps	Detailed Flood Zone Shapefile
7	Approximate Flood Zone Detailed Flood Zone	Flood Zone Shapefile
8	Aerial Photography Flood Zone Shapefile Public Land Survey Shapefiles	Work Map (Hard Copy) ArcReader Map Project (Electronic Work Map)

Table 2

N-FECT Tools		
	Tool	**Function**
Step 1- Assemble DEMs	Add DEM	Adds DEM quadrangle at point clicked
	Mosaic DEMs	Mosaics selected DEMs into single Grid
	Clean Grid	Inserts missing cells into Mosaiced Grid
	Perform Hydrologic Calculations	Fills Grid; calculates and creates Flow Direction, Flow Accumulation and Flow Length Grids
Step 2- Assemble Contours	Add Contour	Adds contour quadrangle at point clicked
	Add Contour Line	Adds a contour line and user entered elevation into a shapefile
	Clip Line	Removes a section of a contour line
Step 3- Digitize Streams	Identify Streams	Uses a Flow Accumulation Grid to delineate streams with a watershed of one-square mile
	Digitize Stream	Used to digitize a stream
	Flip Tool	Orientates the stream downstream
	Manning's n	Allows the user to enter a Manning's *n* value
Step 4- Calculate Base Flood Elevations	Stream Slope Processor	Clips the stream between contours then calculates the slope and upstream and downstream elevations
	Digitize Cross-Sections	Used to enter cross-sections into the cross-section shapefile
	Adjust Flow/Elevation	Used to enter known flows and elevations for a crosssection into the shapefile
	Compute Flood Flow and Depth	For each selected cross-section calculates the flood flow, the corresponding normal depth, the channel invert elevation and the flood stage elevation
	Create one-foot BFE Contours	Uses cross-section elevations to calculate 1-foot BFE contours along the stream
Step 5- Map Flood Zone	Create TIN	Used to create the ground surface TIN and water surface TIN
	Calculate Flood Zone	Calculates the raw flood zone by comparing the ground and water TINs
Steps 6 & 7 – Editing	Edit Tools	Used to modify flood zone shapefiles
Step 8- Work Maps	Create Maps	Used to automatically create map layouts for each quadrangle in the area of interest

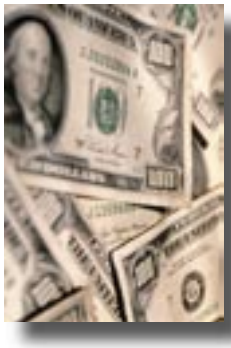
Progress

In 1999, using approximate methods the State delineated floodplains by hand in half of one county at approximate 1/10th of a mile per hour. In 2000, floodplains in five counties were delineated using Arc/Info for the regional regression calculations, BOSS RiverCad for the normal depth calculations, and again Arc/Info for the flood delineation. Using that system, the State mapped at a rate of approximately 1 mile per hour, a ten-fold increase. In 2001, floodplains in seven more counties were mapped using N-FECT tools for the regression equation, a custom ArcGIS extension normal depth calculator, and Arc/Info for the flood delineation. The system delineated floodplains at a rate of 2 miles per hour. This year, the State will delineate floodplains in seven counties using the most recent system of N-FECT tools at a rate of approximately 5 miles per hour.

The N-FECT tools have also been applied to site-specific base flood elevation requests. This has improved the customer service by reducing the amount of time necessary to complete a BFE request by more than 75% and also improving the data returned to the client.

Results

Since the onset of the Nebraska Large Area Mapping Initiative, the State of Nebraska has mapped over 10,000 miles of rivers and streams at an average cost of $30 per mile. Currently 38 counties, approximately half of the state's area, remain to be mapped. With the latest set of tools, the rate at which stream miles are mapped is expected to increase and the average per mile cost is expected to decrease. The final mapping product complies with FEMA's *Specifications and Guidelines for Flood Hazard Mapping Partners*, and the data is compliant with the DFIRM database requirements.



References

Cordes, K.E. and R.H. Hotchkiss. 1993. Design Disharge of Culverts. NDOR Research Project no. RES-1. Lincoln, NE: University of Nebraska-Lincoln Civil Engineering Department.

Federal Emergency Management Agency. 2002. Guidelines and Specifications for Flood Hazard Mapping Partners. Washington D.C.: Federal Emergency Management Agency.